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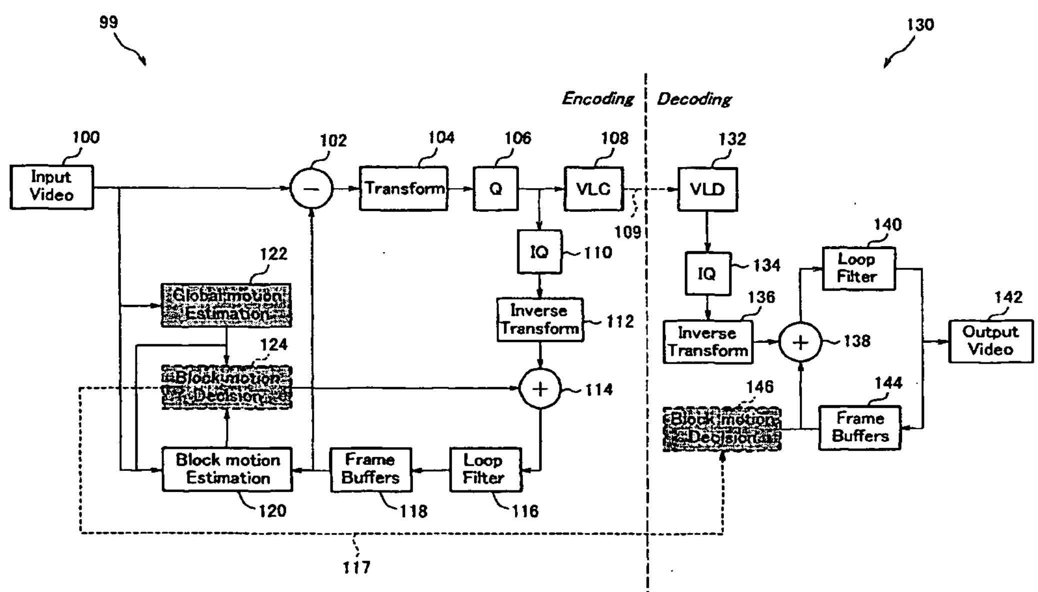
(54) Title: METHOD AND APPARATUS FOR MOTION VECTOR CODING WITH GLOBAL MOTION PARAMETERS



(57) Abstract: A global motion vector coding scheme is used for coding or decoding an image. Global motion parameters are associated with a current image frame. Local motion vectors are derived from the global motion parameters for individual macroblocks in the current image frame. The local motion vectors are then used to identify reference blocks in a current reference frame. The reference blocks are then used to either encode or decode the macroblocks in the current image frame.

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DESCRIPTION

METHOD AND APPARATUS FOR MOTION VECTOR CODING WITH GLOBAL MOTION PARAMETERS

BACKGROUND

Global motion compensation (GMC) techniques, such as the “sprite” coding technique used in MPEG-4 and a “reference picture resampling” technique in Annex P of H.263+, have been used in advanced video coding. These techniques usually follow similar steps.

Referring to FIG. 1, for each current image frame 12, a reference image 14 is derived based on global motion vectors 16. The global motion vectors 16 take into account global image changes between the previous image frame 18 and the current image frame 12. For example, the global motion vectors 16 account for changes in camera angle, camera zooming, etc. that have occurred between frame 18 and 12. The current image 12 is then coded and decoded using the reference frame 14. For example, the portion of an image in MacroBlock (MB) 20 may be exactly the same in the associated macroblock 22 in reference image 14. If this is the case, then the image information in macroblock 20 does not have to be encoded. The image data in block 22 in reference frame 14 can be copied into macroblock 20 of current image 12.

These GMC techniques have shown their advantages in low-bit-rate video coding by reducing the bit rate and enhancing the visual quality. However, GMC increases computational complexity. For each current image frame 12, the reference image 14 has to be reconstructed or updated in both the encoder and decoder based on the global motion vector 16. This can be especially expensive on the decoder side in terms of computation and memory space.

In other situations, an object may change position from the previous image 18 to the current image 12. A local motion vector 26 identifies where the image information in macroblock 20 has moved from the previous image frame 18. The only information that has to be encoded for macroblock 20 is the local motion vector 26 and any residual differences between the image information in macroblock 20 and the image information in macroblock 28. This local motion vector video coding technique is less computationally complex than GMC but typically requires more bits since the local motion vectors 26 have to be separately encoded and then transmitted or stored for each macroblock 20 in image 12.

The present invention addresses this and other problems associated with the prior art.

SUMMARY OF THE INVENTION

A global motion vector coding scheme is used for coding or decoding an image. Global motion parameters are associated with a current image frame. Local motion vectors are derived from the global motion parameters for individual macroblocks in the current image frame. The local motion vectors are then used to identify reference blocks in a current reference frame. The reference blocks are then used to either encode or decode the macroblocks in the current image frame.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagram showing a prior art encoding syntax.

FIG. 2 is a diagram of a prior art syntax used for an encoded bit stream.

FIG. 3 is a diagram of a syntax used for Global Motion Vector Coding (GMVC).

FIGS. 4 and 5 are tables of code words used for GMVC.

FIG. 6 is a diagram showing global motion vectors used for GMVC.

FIG. 7 is a diagram showing how local motion vectors are used to reconstruct Macroblocks (MBs) during GMVC.

FIG. 8 is a diagram showing how local motion vectors are used to reconstruct subblocks during GMVC.

FIG. 9 is a block diagram showing an encoder and decoder that perform GMVC.

FIG. 10 is a table showing the results of GMVC.

DETAILED DESCRIPTION

Global motion parameters are used for local motion vector coding to eliminate the need for reconstructing a reference picture in either the encoder or decoder.

Motion Vector Coding with Global Motion Parameters

FIG. 2 illustrates a prior art bit syntax used for the current TML video codec. The TML video codec is described in a document by Gisle Bjontegaard, entitled: "H.26L Test Model Long Term Number 8 (TML-8) draft0," ITU-T Video Coding Experts Group (VCEG) Meeting, 28 June 2001.

Referring to FIG. 2, a bit stream 30 includes a coded picture header 32 followed by the coding of all image Macroblocks 34 (MBs) in an image frame. Each individual MB 34 is coded and includes an MB mode 36, the necessary local motion vector for Inter-frame prediction (Inter MB) or intra-frame prediction (Intra MB). Inter-frame prediction refers to using a macroblock from a previously derived reference frame for encoding and decoding the MB. Intra-frame prediction refers to using a macroblock in the same image frame for encoding and decoding. The individual MBs 34 are followed by transform coefficients 39 for image residuals.

FIG. 3 shows a coding syntax used for GMVC (Global Motion Vector Coding). A coded GMVC bit stream 40 includes the picture headers 42 similar to the picture headers 32 in FIG. 2. For each INTER frame, a GMVC_flag 44 is added right after the picture header 42 to signal if GMVC is on or off for the current frame. The codeword numbers for the GMVC_flag 44 are listed in Table 1 of FIG. 4. If GMVC is off, then the remainder of the syntax for the bit stream 40 will be similar to the bit stream syntax shown in FIG. 2. Comparing the original TML syntax in FIG. 2 with the GMVC syntax shown in FIG. 3, only one extra bit is needed per inter frame for the GMVC_flag 44.

If GMVC is on, global motion vectors (GMV's) 46 are coded after the GMVC_flag 44 followed by MBs 48. Each MB 48 includes a MB mode 50 that identifies the coding mode used in the MB 48. If a conventional coding mode is identified, then a motion vector 52 is encoded for the MB similar to FIG. 2.

If the MB mode 50 is determined to be one of the GMVC modes, no motion vector is coded since the motion vectors for all sub blocks in that MB 48 are derived from the GMV's 46 through bilinear interpolation.

Table 2 in FIG. 5 lists the codeword values for the different MB modes 50 used in the GMVC syntax 40 shown in FIG. 3. The GMVC modes identify the MB sizes used to encode the image. For example, when the GMVC flag 44 is off, and the MB mode has a value of 3, local motion vectors are encoded for 8 × 8 pixel MBs followed by any residuals 54. If the GMVC flag 44 is on and the MB mode is x, then a GMVC copy is indicated and no local motion vectors or residuals are encoded for the macroblock. The symbol "x" refers to the COPY or GMVC_COPY not having to be coded explicitly. For example, run length coding can be used to signal the COPY or GMVC_COPY. If the GMVC flag 44 is on and the MB

mode is zero, then no local motion vectors are encoded and only residuals are encoded for the macroblock.

Motion vector calculation

Referring to FIG. 6, assume an image frame 60 has a size H × V. The motion vectors $\underline{v}^{00}$, $\underline{v}^{H0}$, $\underline{v}^{0V}$, and $\underline{v}^{HV}$ are used for bilinear motion vector interpolation and represent the motion vectors of four 4 × 4 subblocks at the four corners (0,0), (H-4, 0), (0, V-4), and (H-4, V-4), of the frame 60, respectively. The number "4" is one example that uses a 4 × 4 pixel subblock size. However, the value can change according to the subblock size. For example, for a 8 × 8 subblock size, the motion vectors are located at four corners (0,0), (H-8), (0,V-8), and (H-8, V-8). The motion vector of a subblock with its upper-left pixel at (x, y) is derived as

$$\underline{v}(x,y) = \underline{r}^{0} + \left(\frac{x}{H-4}\right)\underline{r}^{x} + \left(\frac{y}{V-4}\right)\underline{r}^{y} + \left(\frac{x}{H-4}\right)\left(\frac{y}{V-4}\right)\underline{r}^{xy} \qquad (1)$$

where $\underline{r}^{0}$, $\underline{r}^{x}$, $\underline{r}^{y}$, and $\underline{r}^{xy}$ are defined as the following

$$\underline{r}^{0} = \underline{v}^{00}$$

$$\underline{r}^{x} = \underline{v}^{H0} - \underline{v}^{00}$$

$$\underline{r}^{y} = \underline{v}^{0V} - \underline{v}^{00}$$

$$\underline{r}^{xy} = \underline{v}^{00} - \underline{v}^{H0} - \underline{v}^{0V} + \underline{v}^{HV}$$

The resolution of the local motion vectors can vary. In one example, the local motion vectors are represented in ¼ pixels. So a motion vector value of 1 means ¼ pixel and a motion vector of 4 means 1 pixel. To prevent mismatch during encoding/decoding, the output of Eq. (1) may be rounded to the nearest integer or rounded up when the fraction is exactly ½. For easy implementation, Eq. (1) can be implemented as follows:

$$\underline{v}(x,y) = round\left[\frac{\underline{r}^{0}(H-4)(V-4) + x(V-4)\underline{r}^{x} + y(H-4)\underline{r}^{y} + xy\underline{r}^{xy}}{(H-4)(L-4)}\right] \qquad (2)$$

If the GMVC_flag 44 is set to "on" for a certain image frame, the horizontal and vertical components of $\underline{v}^0$, $\underline{v}^x$, $\underline{v}^y$, and $\underline{v}^{xy}$ are coded in the global motion vector parameters 46 right after the GMVC_flag 44, as illustrated in FIG. 3. The codebook for the GMV's can be chosen to be similar to codebooks used for other encoding schemes, such as the Motion Vector Difference (MVD). The MVD is the difference between a local motion vector (MV) and a local motion vector prediction (MVP), i.e., MV=MVP+MVD. The denominator $(H-4)(L-4)$ in Eq. 2 is a constant. Once the frame size is determined, the division can be easily replaced by a multiplication and then a shift. Therefore, the computation requirement on the decoder side is minor.

Referring to FIG. 7, the motion vectors for each MB in a GMVC mode image frame are derived using Eq. (1). For example, four global motion vectors 70 are associated with the four corners of a current image frame 72. The MB 74 is currently being decoded. The MB mode 50 (FIG. 3) identifies MB 74 as GMVC encoded. Accordingly, the decoder identifies the x pixel position 76 and the y pixel position 78 for the upper left hand corner of MB 74. The x and y pixel positions are then used along with the global motion vectors 70 as previously described in EQ. 1 to generate a local motion vector 80.

The local motion vector 80 points to a reference MB 82 in a reference frame 84. If the GMVC code for MB 74 indicates a GMVC copy (FIG. 5), then the contents of reference MB 82 are copied into the MB 74. If the GMVC code for MB 74 is not copy, then residuals exist in the coded bit stream for the MB 74. The decoder adds the residuals to the reference MB 82 to derive the image values for MB 74.

FIG. 8 shows how GMVC can encode 4 × 4 subblocks 86 in the same MB 74. In this example, the subblocks are 4 × 4 arrays of pixels. However the MBs and subblocks can be any size. Local motion vectors 88 are derived for each individual subblock 86 in MB 74

using Eq. 1. For example, a local motion vector for subblock 86A is derived by first identifying the x and y location 90 in the upper left hand corner. The global motion vectors 70 are then interpolated to the x and y location 90 using equation 1 to derive local motion vector 88A.

The local motion vector 88A points to subblock 92 in reference frame 84. The reference subblock 92 is then used to construct the image in subblock 86A. The other subblocks 86 in MB 74 are decoded in a similar manner. For example, the upper left corner of subblock 86B is at location 94 in image frame 72. If the subblocks are 4 × 4 pixel sizes, then subblock 86B is at location (x + 4, y) in relation to subblock 86A at location (x, y). The global motion vectors 70 are interpolated to pixel location (x +4, y) using Eq. 1 to derive the local motion vector 88B. The local motion vector 88B is then used to identify reference subblock 96 in reference frame 84. The image information in subblock 96 is then used to reconstruct the image for subblock 86B in the current image frame 72. A similar process is conducted for the other subblocks 86 in MB 74.

As shown in Table 2 of FIG. 5, there are two GMVC modes for the macroblock.

First is the GMVC_COPY mode. This is similar to the "skip" or "copy" mode used in current video coding standards. The traditional "copy" mode indicates a macroblock that is a direct "copy" of the macroblock at the same location in the current reference frame. The difference in "GMVC_COPY" is that the "copy" of each motion compensated block in the GMVC_COPY mode will follow the motion vectors derived by Eq. (1). There is no conventional "copy" mode once the GMVC_flag is "on" for an image frame.

The second GMVC mode is GMVC_16 mode. If a macroblock is GMVC_16 mode, then only the residual transform coefficients are coded into the bit stream. The local motion vectors for that macroblock will be derived from Eq. (1). The difference between the

reference frame macroblock pointed to by the local motion vector and the current macroblock is encoded as the residual transform coefficients.

In the current TML syntax, the "copy" mode is replaced by the "GMVC_COPY" mode for GMVC frames and a new mode "GMVC_16" is added to the other possible coding modes for GMVC frames. For all the non-GMVC modes in the GMVC frame, local motion vectors are coded explicitly into the bit stream as previously shown in FIG. 2.

It is not necessary to code the "COPY" or "GMVC_COPY" mode explicitly. Run-length coding can be used to increase coding efficiency. Instead of generating a copy codeword for each MB in a string of CMVC_COPY mode MBs, the number of MBs that are GMVC_COPY mode can be signaled before each non-GMVC_COPY MB.

When camera motion is present in a video sequence, the number of GMVC_COPY MBs tends to be larger then in convention COPY MB in the original TML bit stream. Thus, more bit savings are realized when run-length coding is implemented for the "GMVC_COPY" mode. Since GMVC modes tend to give true motion vectors, which are more correlated than that without GMVC modes, the visual quality and coding efficiency of image frames are also improved.

FIG. 9 shows a block diagram of an encoder and decoder that implement the GMVC scheme. The encoder and decoder can be implemented in any programmable processor device or in discrete circuitry. The GMVC scheme can be used for any image application such as video phones, cameras, video cameras, television, streaming video applications or in any other applications where image data is encoded or decoded.

The encoder 99 receives image frames from an input video source 100. Other than boxes 122 and 124 the encoder circuitry is similar to prior encoders. The image frames are transformed in box 104, such as with a Discrete Cosine Transform. The image frames are

quantized in box 106 and then variable length coded in box 108. The output of box 108 is encoded image data.

The quantized image frames are inverse quantized in box 110 and inverse transformed in box 112. A loop filter is applied in box 116 and the resulting reference frames are stored in frame buffer 118. Block motion estimation is performed in block 120 by comparing the current image frame with a current reference frame. The block motion estimation 120 generates local motion vectors that are encoded along with any residuals generated from comparator 102.

Global motion parameters are estimated in box 122 and used by a block motion decision box 124 to determine whether GMVC coding is used for particular image frames. If GMVC coding is used, the global motion parameters estimated in box 122 are added to the encoded bit stream 109 along with the code words that indicate which coding mode is used for the MBs.

The decoder 130 performs variable length decoding in box 132 and inverse quantization in box 134. An inverse transform in box 136 outputs the inverse transformed bit stream to an adder circuit 138. Reference frames in frame buffers 144 are also supplied to the adder 138 and are used in combination with the output from inverse transform 136 to reconstruct the current image frame. The output from adder 138 is passed through a loop filter in box 140 and then output as decoded video in box 142.

A block motion decision box 146 in the decoder decides if GMVC is performed on particular MBs in particular image frames based on the GMVC_flag 44 and GMVC mode 50 (FIG. 3) generated by block motion decision block 124.

Test Results

FIG. 10 shows the results of tests conducted mainly following the "Simulation Conditions" specified in VCEG-M75 described by Gisle Bjontegaard, "Recommended Simulation Conditions for H.26L," document VCEG-M75, ITU- T Video Coding Experts Group (VCEG) Meeting, Austin, TX, USA, 2-4 April 2001.

The global motion vector coding scheme is integrated into the TML-8 software to compare against the TML-8 codec. The 300-frame CIF-format "coast-guard" sequence was added to the testing set to demonstrate the advantage of the proposed GMVC technique. The motion search range parameter is set to 16 and the RD optimization option is turned off.

For sequences with global motions or camera motions, such as "foreman", "mobile", "tempete", and "coast-guard", significant bit savings were produced especially in the low-bit-rate cases when Quantization Parameter (QP) values are high. For example, when QP is 28, the bit saving for "foreman" is 11.4%; the bit saving for "mobile" is 10.2%; the bit saving for "tempete" is 8.1%; and the bit saving for "coast-guard" is 19.5%. Since the motion vector coding becomes less significant part of the whole bit stream at high bit rates, GMVC delivers bit rate and video quality very similar to the original TML-8 codec when QP values are lower.

In the original TML codec, the conventional "copy" mode introduces annoying artifacts when global motion is present in the scene. With the GMVC technique, these artifacts are significantly removed. The GMVC technique gives significant benefit for low-bit-rate video coding by reducing bit rate and enhancing visual quality. The GMVC scheme is especially useful for video applications in the mobile environments where there is large amounts of global or camera motion. Only one bit per frame is required to enable or disable the GMVC scheme when GMVC is not used. Thus, the overhead for coding efficiency is negligible. The GMVC scheme also does not add significant coding complexity to either the encoder or decoder.

The system described above can use dedicated processor systems, micro controllers, programmable logic devices, or microprocessors that perform some or all of the operations. Some of the operations described above may be implemented in software and other operations may be implemented in hardware.

For the sake of convenience, the operations are described as various interconnected functional blocks or distinct software modules. This is not necessary, however, and there may be cases where these functional blocks or modules are equivalently aggregated into a single logic device, program or operation with unclear boundaries. In any event, the functional blocks and software modules or described features can be implemented by themselves, or in combination with other operations in either hardware or software.

Having described and illustrated the principles of the invention in a preferred embodiment thereof, it should be apparent that the invention may be modified in arrangement and detail without departing from such principles. Claim is made to all modifications and variation coming within the spirit and scope of the following claims.

CLAIMS

1. A method for coding or decoding an image, comprising:

providing global motion parameters associated with a current image frame;

deriving local motion vectors from the global motion parameters for individual macroblocks in the current image frame;

using the local motion vectors to identify reference blocks in a reference frame; and

using the identified reference blocks to encode or decode the macroblocks in the current image frame.

2. A method according to claim 1 including:

identifying four global motion vectors associated with corners of the current image frame; and

generating the local motion vectors by interpolating the four global motion vectors to locations of the macroblocks in the current image frame.

3. A method according to claim 1 including deriving the local motion vectors from the global motion parameters as follows:

$$\underline{v}(x,y) = \underline{r}^0 + \left(\frac{x}{H-4}\right)\underline{r}^x + \left(\frac{y}{V-4}\right)\underline{r}^y + \left(\frac{x}{H-4}\right)\left(\frac{y}{V-4}\right)\underline{r}^{xy} \qquad (1)$$

where $\underline{v}^{00}$, $\underline{v}^{H0}$, $\underline{v}^{0V}$, and $\underline{v}^{HV}$ represent the global motion parameters at four corners of the current image frame, (0,0), (H-4, 0), (0, V-4), and (H-4, V-4), respectively; x and y represent an upper-left pixel location for the macroblock; and $\underline{r}^0$, $\underline{r}^x$, $\underline{r}^y$, and $\underline{r}^{xy}$ are the following:

$$\underline{r}^0 = \underline{v}^{00}$$

$$\underline{r}^{x} = \underline{v}^{H0} - \underline{v}^{00}$$

$$\underline{r}^{y} = \underline{v}^{0V} - \underline{v}^{00}$$

$$\underline{r}^{xy} = \underline{v}^{00} - \underline{v}^{H0} - \underline{v}^{0V} + \underline{v}^{HV}$$

4. A method according to claim 1 including generating codewords that identify the macroblocks that use the global motion parameters to generate associated local motion vectors.

5. A method according to claim 1 including:

using the derived local motion vectors to identify reference blocks in the reference frame that are substantially the same as the macroblocks in the current image frame; and

encoding the macroblocks as copy type macroblocks that are decoded by copying the identified reference blocks into the macroblocks.

6. A method according to claim 5 including:

identifying residuals between the reference blocks and the macroblocks; and

encoding only the residuals for the macroblocks.

7. A method according to claim 1 including:

receiving an encoded bit stream including macroblocks identified as global motion vector coded and either copy type or residual type;

deriving local motion vectors only for the global motion vector coded macroblocks;

using the derived local motion vectors to identify reference blocks in the reference frame;

copying the identified reference blocks for the copy type macroblocks; and

adding encoded residuals to the identified reference blocks for the residual type macroblocks.

8. A method according to claim 1 including:

encoding and decoding some of the macroblocks in the current image frame using global motion vector coding where the global motion parameters are used to generate local motion vectors for the macroblocks; and

encoding and decoding other macroblocks in the current image frame using another coding scheme.

9. A method according to claim 1 including:

generating subblock local motion vectors for individual subblocks in the same macroblocks using the global motion parameters;

identifying individual reference subblocks in the reference frame pointed to by the subblock local motion vectors; and

separately encoding and decoding the subblocks using the identified reference subblocks.

10. A decoder, comprising:

a processor decoding encoded image frames by deriving local motion vectors for identified macroblocks, the local motion vectors derived from global motion estimation parameters associated with the image frames, the processor using the local motion vectors to

identify reference blocks in a current reference frame and then using the reference blocks to reconstruct the macroblocks in a current frame.

11. A decoder according to claim 10 wherein the processor generates the local motion vectors by interpolating the global motion estimation parameters to locations of the macroblocks in the current frame.

12. A decoder according to claim 10 wherein the processor detects code words included along with the encoded image frames that identify global motion vector coded macroblocks.

13. A decoder according to claim 12 wherein the code words indicate when the macroblocks are a direct copy of the reference blocks.

14. A decoder according to claim 12 wherein the code words indicate when residuals are added to the reference blocks to reconstruct the macroblocks.

15. A decoder according to claim 10 wherein the processor uses the global motion estimation parameters to generate local motion vectors for different subblocks, the processor using the local motion vectors to identify different reference subblocks in the current reference frame and then using the identified reference subblocks to reconstruct the subblocks in the current frame.

16. An encoder, comprising:

a processor encoding an image frame by encoding a set of global motion estimation parameters for an image frame and identifying macroblocks in the image frame that have local motion estimation parameters derived during decoding from the global motion estimation parameters.

17. An encoder according to claim 16 wherein the global motion estimation parameters include global motion vectors associated with corners of the image frame.

18. An encoder according to claim 17 wherein the processor compares the global motion estimation parameters with block motion estimation parameters to determine which macroblocks use the local motion estimation parameters derived from the global motion estimation parameters.

19. An encoder according to claim 16 wherein the processor generates codewords that identify the macroblocks that derive the local motion estimation parameters from the global motion estimation parameters.

20. An encoder according to claim 16 wherein the processor identifies macroblocks that are directly copied from reference blocks pointed to by the local motion estimation parameters derived from the global motion estimation parameters.

21. An encoder according to claim 16 wherein the processor encodes residuals for the identified macroblocks but no local motion estimation parameters.

22. An encoder according to claim 16 wherein the processor performs run length coding on the encoded image frame.

23. An encoder according to claim 16 wherein the macroblocks are $N \times N$ pixel arrays, where N is an integer; the subblocks are $M \times M$ pixel arrays, where M is an integer less than or equal to N.

FIG.1
(PRIOR ART)

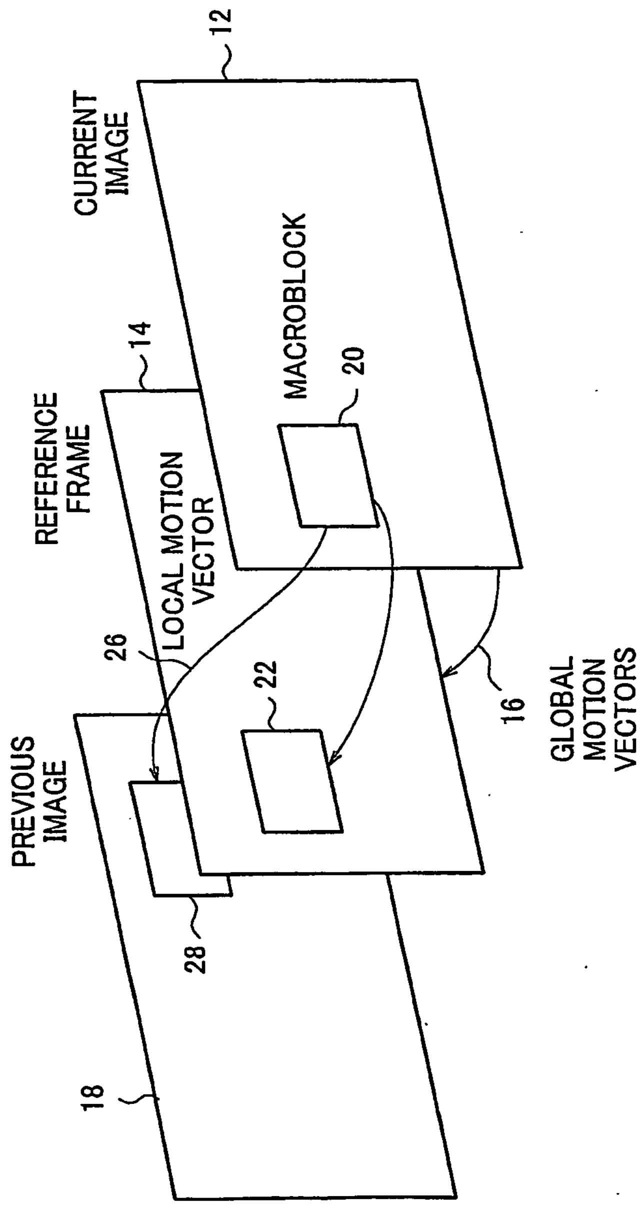


FIG.2
(PRIOR ART)

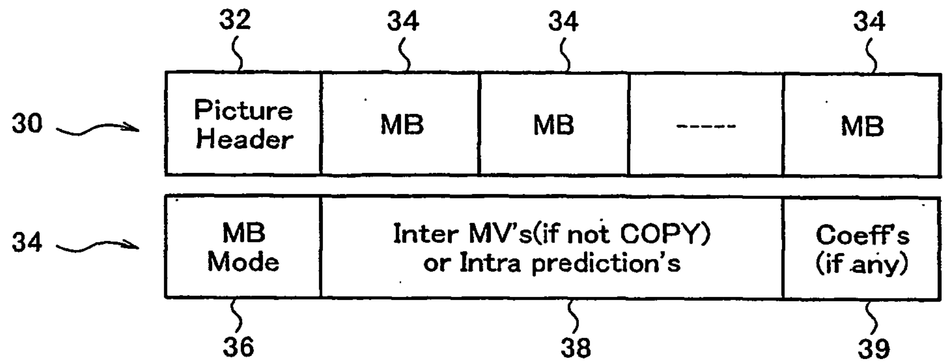


FIG.3

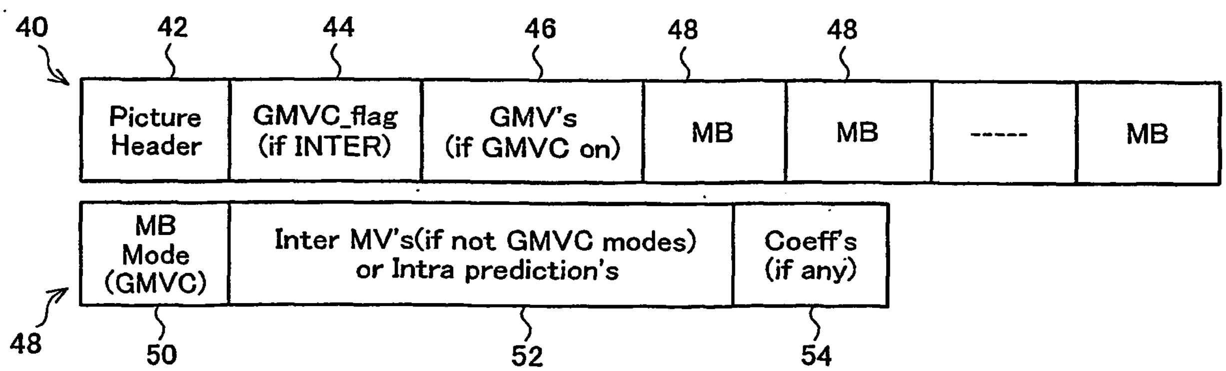


FIG.4

Table 1.Codeword number of GMVC_flag

code number	GMVC_flag	comment
0	0	GMVC off
1	1	GMVC on

FIG.5

Table 2.Codeword number of MB modes

code number	GMVC off	GMVC on	comment
X	COPY	GMVC_COPY	GMVC modes
0	16X16	GMVC_16	
1	16X8	16X16	non-GMVC modes
2	8X16	16X8	
3	8X8	8X16	
4	8X4	8X8	
5	4X8	8X4	
6	4X4	4X8	
7	intra 4X4	4X4	
8	0,0,0	intra 4X4	
¦	¦	¦	

FIG.6

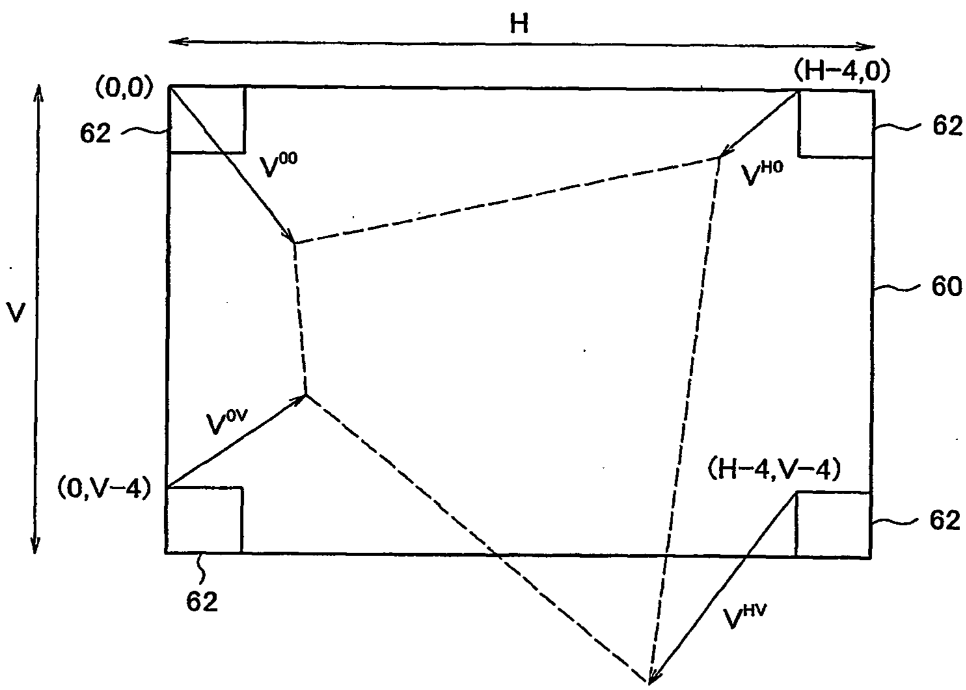
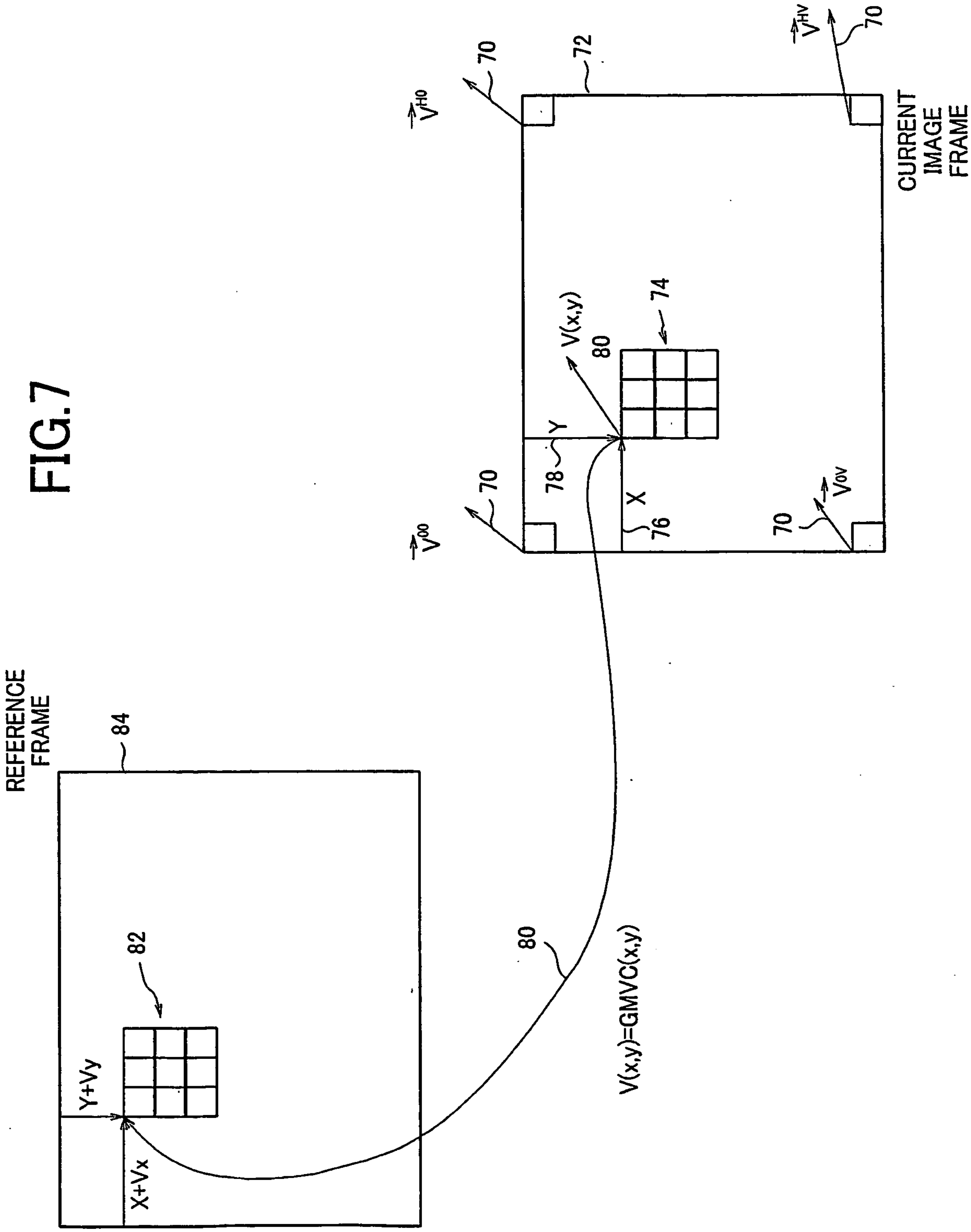


FIG.7


REFERENCE FRAME
84
82
Y+Vy
X+Vx
80
V(x,y)=GMVC(x,y)
CURRENT IMAGE FRAME
72
70
70
70
70
V^H0
V^HV
V^00
V^0V
74
V(x,y)
80
Y
X
76
78

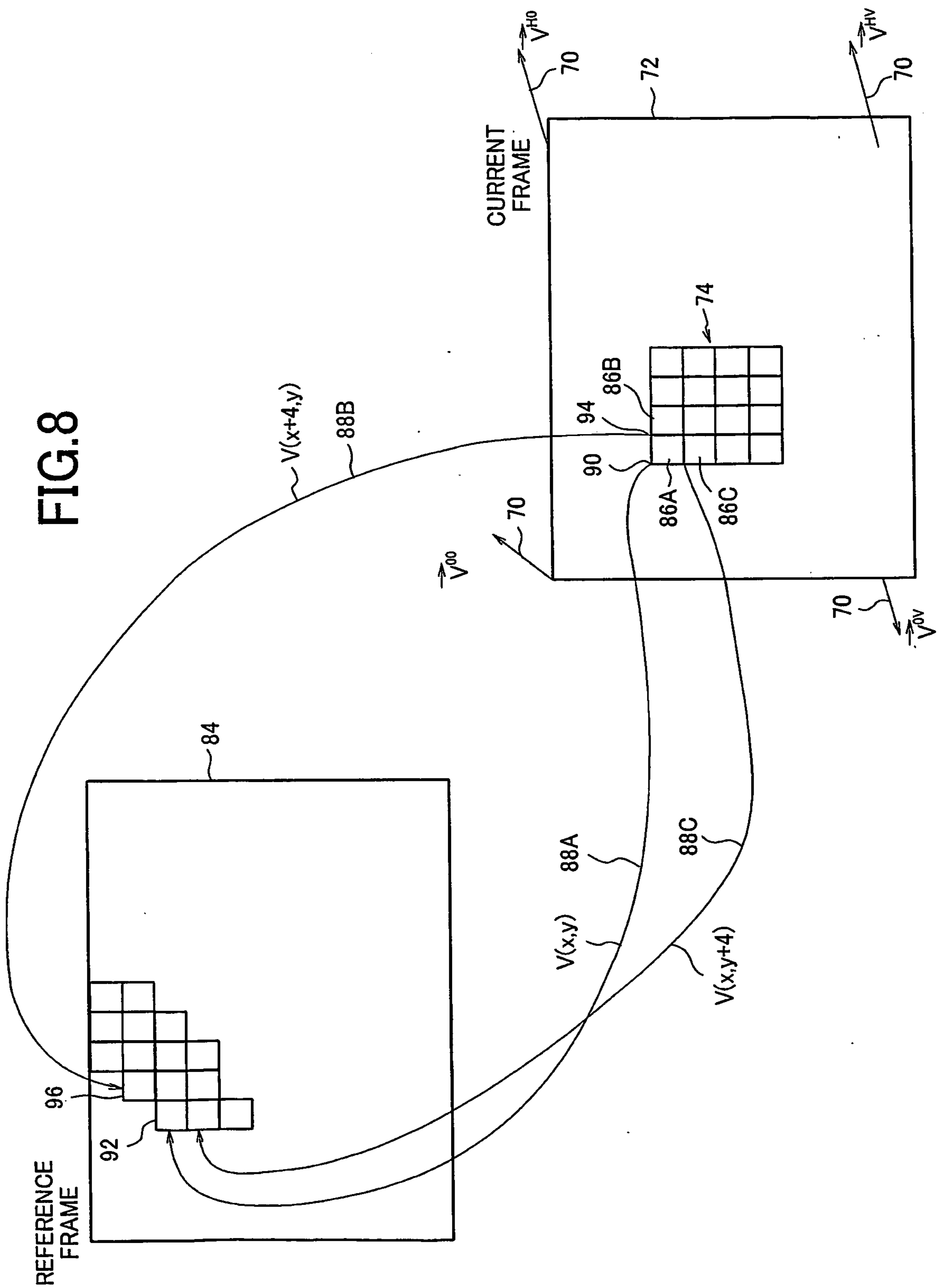

CURRENT FRAME
REFERENCE FRAME
70
72
74
84
86A
86B
86C
88A
88B
88C
90
92
94
96
V(x,y)
V(x+4,y)
V(x,y+4)

FIG.8

FIG.9

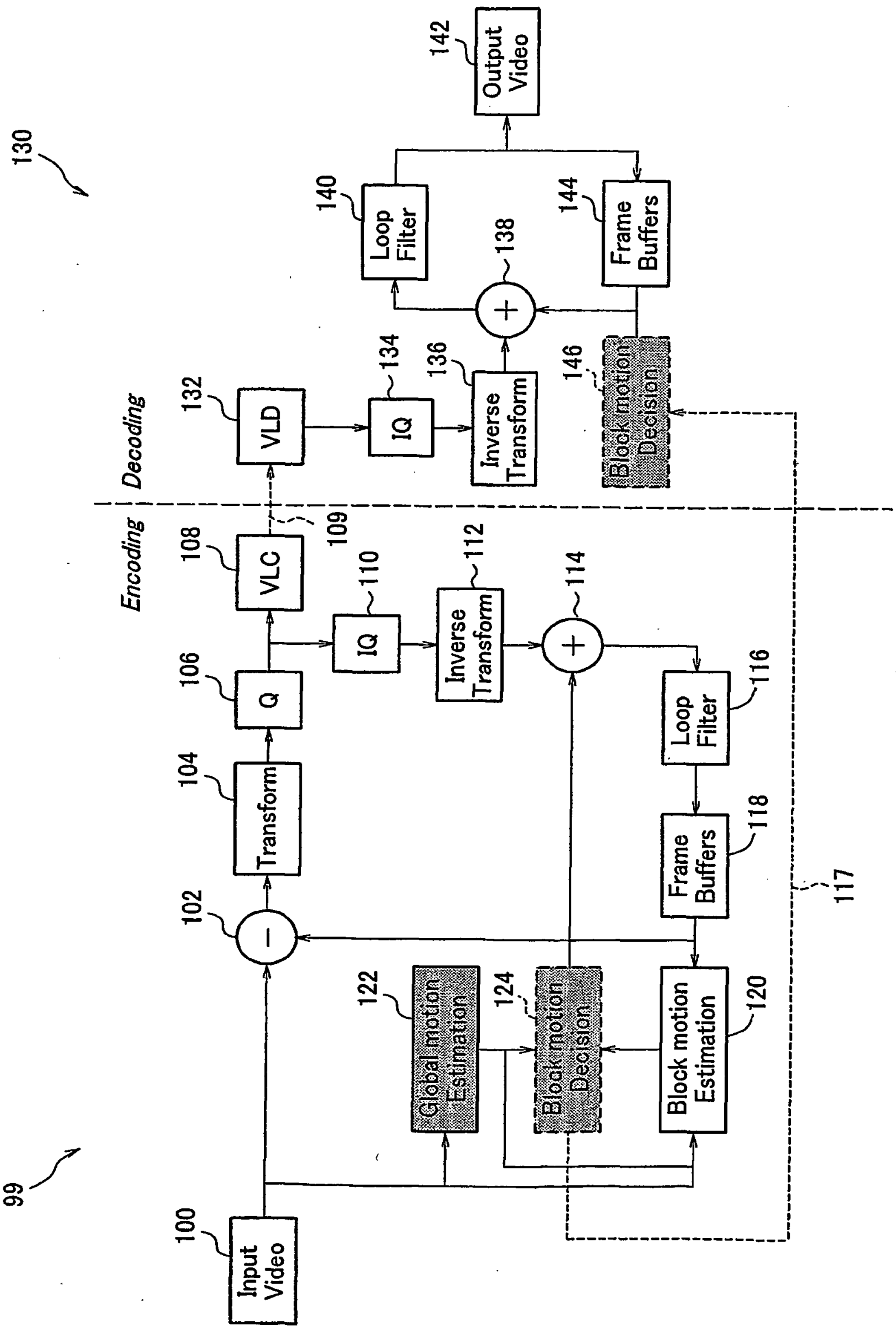

99
100
Input Video
102
104
Transform
106
Q
108
VLC
109
110
IQ
112
Inverse Transform
114
116
Loop Filter
118
Frame Buffers
117
120
Block motion Estimation
122
Global motion Estimation
124
Block motion Decision
Encoding
Decoding
130
132
VLD
134
IQ
136
Inverse Transform
138
140
Loop Filter
142
Output Video
144
Frame Buffers
146
Block motion Decision

FIG.10

Comparison of TML-8 and the proposed GMVC

sequences	number of frames	QP	PSNR(Y) (TML8)	bitrate (TML8)	PSNR(Y) (GMVC)	bitrate (GMVC)	GMVC average bitsavings(avsnr)	GMVC average dB gain (avsnr)
container_qcif	100	16	36.012	26841	36.072	26973	0.41%	0.017
	100	20	33.315	14686	33.374	14982		
	100	24	30.496	8872	30.625	8992		
	100	28	27.72	5501	27.89	5546		
news_qcif	100	16	36.748	50387	36.771	50306	0.32%	0.019
	100	20	33.773	30616	33.807	30610		
	100	24	30.807	18393	30.878	18571		
	100	28	27.912	11138	27.92	11217		
foreman_qcif	100	16	36.03	77341	36.015	76953	3.75%	0.197
	100	20	33.312	47049	33.254	45815		
	100	24	30.759	29654	30.691	27729		
	100	28	28.123	19002	27.987	16829		
silent_qcif	150	16	35.799	62703	35.803	62584	1.54%	0.075
	150	20	33.067	36789	33.105	36700		
	150	24	30.446	21462	30.528	21341		
	150	28	27.94	12389	28.027	12325		
paris_cif	150	16	35.607	350219	35.627	348976	0.73%	0.037
	150	20	32.541	202010	32.576	201485		
	150	24	29.636	112599	29.65	112559		
	150	28	26.719	63113	26.754	62710		
mobile_cif	300	16	34.009	1658660	33.986	1657004	0.64%	0.028
	300	20	30.738	838637	30.684	833798		
	300	24	27.817	423358	27.672	406809		
	300	28	25.093	252598	24.839	226740		
tempete_cif	260	16	34.95	1275478	34.945	1276031	1.29%	0.053
	260	20	31.931	625722	31.887	619544		
	260	24	29.217	313318	29.134	301817		
	260	28	26.557	176451	26.472	162093		
coast_cif	300	16	34.36	1289113	34.341	1265484	8.23%	0.28
	300	20	31.491	649562	31.457	616242		
	300	24	28.874	307248	28.854	270744		
	300	28	26.548	144230	26.606	116146		
average							2.11%	0.08825

INTERNATIONAL SEARCH REPORT	International application No. PCT/JP02/08390

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl7 H04N7/32

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl7 H04N7/24-7/68

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Japanese Utility Model Gazette 1926-1996, Japanese Publication of Unexamined Utility Model Applications 1971-2002, Japanese Registered Utility Model Gazette 1994-2002, Japanese Gazette Containing the Utility Model 1996-2002

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 9-252470 A(Hitachi, Ltd.) 1997.09.22 column 10, line 42 - column 13, line18 & US 6008852 A1 & EP 797357 A2	1-23
Y	JP 4-3595 A(NEC Corporation) 1992.01.08 claim 4 (Family:none)	1-23
Y	JP 10-290463 A(Nippon Telegraph and Telephone Corporation) 1998.10.27 column 14, line 40 - column 17, line 21 & WO 98/36577 A1 & EP 961499 A1 & KR 2000071047 A	5,7,13,20
Y	JP 10-136375 A(Hitachi, Ltd.) 1998.05.22 column 7, line 13 - column 8, line 13 & US 6256343 B1	9,15,23

☑ Further documents are listed in the continuation of Box C.　　☐ See patent family annex.

* Special categories of cited documents:
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28.11.02	10.12.02

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP02/08390

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 6-245201 A(Kabushiki Kaisha Toshiba) 1994.09.02 column 11, line 12 - column 12, line 7, Table 3 & US 5440345 A & EP 579514 A2	22